U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
A. C. TRUE, DIRECTOR.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1904.

BY

D. W. MAY,
Special Agent in Charge.

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ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION 1904.

By D. W. May, *Special Agent in Charge.*

INTRODUCTION.

The fiscal year 1903–4 is the second twelve months of the existence of the Porto Rico Experiment Station at its new location, Mayaguez. The farm purchased for the use of the station consists of an old sugar plantation which had been allowed to grow up to brush and grass through a number of years. The work, therefore, during this period has continued to be one largely of preparation. By means of an appropriation from the insular government this work of preparing the estate for experimental purposes has been greatly assisted. Unfortunately, however, it was not completed, and the Territorial legislature failed to appropriate anything for completing this work or for furthering certain experimental work that had been undertaken.

A number of changes occurred in the station staff during the year. Frank D. Gardner, special agent in charge, returned to the Bureau of Soils, U. S. Department of Agriculture, in May, and was succeeded by D. W. May, of the Kentucky Agricultural Experiment Station. J. van Leenhoff, jr., resigned and entered the Bureau of Plant Industry, U. S. Department of Agriculture. E. G. Bowersox has been succeeded as farm superintendent by E. F. Curt. E. C. Howe, clerk and stenographer, has been succeeded by Miss Jessie F. Springer. The position of horticulturist has been filled by the appointment of H. C. Henricksen, of the tropical laboratory of the Bureau of Plant Industry, Miami, Fla. Animal industry will be taken up by the special agent in charge, D. W. May. As soon as the funds of the station will allow a chemist should be added to the staff. This is necessary for the proper study of the soils, fertilizers, cave deposits of guanos, and other resources and products of Porto Rico.

BUILDINGS AND REPAIRS.

The plant house, a bamboo frame covered with cheese cloth, has proven unsatisfactory for the work, owing to its instability and to the fact that plants in this inclosure were kept too moist, causing damping off. A new plant house has been constructed of wood,

the sides built of slats placed far enough apart to allow for the circulation of air.

The lowlands have been drained, thereby permitting better and more constant cultivation. An insular appropriation of $950 was expended for the purpose of tiling these lands, and this amount includes the purchase of a tile-making machine for $300. The system of drainage is working admirably and has already caused a change in the physical condition of the soils.

Another insular appropriation of $650 has been expended for fencing, and while the work is not complete, yet it has enabled us to inclose nearly the entire tract and to build a number of cross lines. The irregular form of the station grounds gives us a border line of something like 4½ miles.

A further insular appropriation of $100 has been used for painting the various buildings of the station.

The sum of $500 of the insular appropriation was used in the coffee investigations, and $500 in the study of tobacco culture on the island. The results of this work are reported herein by J. W. van Leenhoff and J. van Leenhoff, jr., respectively.

By cooperation with the irrigation and drainage investigations of the Office of Experiment Stations, $335 has been expended in a system for irrigating some of the lands of this station. (Pl. XVI, fig. 1.) A dam has been constructed, ditches built, and irrigation will be employed in the production of various crops, and especially in growing lowland rice. (Pl. XVI, fig. 2.) By the use of hydraulic rams the water will also be employed in the propagating gardens and nursery. With a growing season of twelve months in the year and plenty of water available at all times, it is expected to secure very quick and very favorable results. In all about 40 acres will be irrigated.

As detailed in other portions of this report, the continuation of orchard planting is progressing and the other lands of the station are being brought under cultivation as rapidly as possible.

Meteorological observations have been carried on by members of the station staff at Mayaguez, Aguas Buenas, and "La Carmelita" for the Weather Bureau of the U. S. Department of Agriculture.

TRAVEL.

During the year the special agent in charge made a trip to Washington for conference with the Director of the Office of Experiment Stations and for preparing his annual report. The entomologist and botanist made a trip to Washington and St. Louis. At the latter point he assisted in placing and labeling the Porto Rico Station

FIG. 1.—DAM CONSTRUCTED FOR IRRIGATION PURPOSES AT PORTO RICO STATION.

FIG. 2.—FIELD TO BE IRRIGATED.

exhibit at the exposition. Different members of the staff have made numerous trips in and about the island, meeting with fruit growers and other associations and in conference with leading planters.

LABOR.

The station has employed a great deal of labor during the fiscal year. This has been necessary by reason of the large amount of work required for bringing the station farm into cultivation. Labor varies in price from 40 to 60 cents a day on the plantations. The experiment station has been able to secure excellent hands at from 50 to 55 cents per day. This labor requires, however, constant supervision, as the work is very often new to these men, and they have to be taught the use of new tools and implements.

The administrative work of the station is growing in extent and requires a great deal of the time of the special agent in charge, especially as he is also disbursing agent. Through the efforts of Miss Jessie F. Springer the mailing list has been greatly increased and the names of representative planters secured. This has been accomplished by the assistance of the various alcaldes of the island, who have, upon request, sent in the names of the more progressive farmers in their respective districts.

The station has distributed a large number of packets of seed, a large amounts of Sea Island cotton seed, and various economic plants for trial in different sections of the island.

The equipment of the station has been increased by various tools and implements, including a mower, and by the purchase of four American mules.

PUBLICATIONS.

During the year the Porto Rico Station has issued one bulletin and two circulars.

Bulletin No. 4, Propagation and Marketing of Oranges in Porto Rico, describes the various methods of propagating oranges, gives directions for the formation of seed beds and nurseries, and transplanting and cultivation of the orange, and offers suggestions for picking, grading, packing, and shipping oranges to market.

Circular No. 4, Control of the Brown Ant, gives an account of the injury caused by the brown ant (*Solenopsis geminata*) in orange orchards, where it frequently causes extensive damage, particularly to young trees, by girdling them in its attempt to secure a rapid flow of gum from the trees. Experiments with girdle paints showed that a cheap and efficient means of combating the ants was possible.

Circular No. 5, Coffee Planting in Porto Rico, describes the investigations that have been carried on by the experiment station in the

improvement of an old coffee plantation and in the establishment of a new one. The information is drawn from investigations carried on at the Carmelita Substation.

AGRICULTURAL POSSIBILITIES.

A great many inquiries are received from time to time from persons in various States, as well as local parties, regarding the agricultural possibilities of Porto Rico. It is the aim of the station to obtain such information as will enable it to answer inquiries fully, and to place before the people of the island and investors the possibilities in agriculture. Horticultural enterprises are under way in several parts of the island, especially orange planting, and it seems probable that such products will ultimately form an important part of our exports. For a quick-growing export crop sugar is at present the most developed and forms the larger part of our shipments. Much remains to be done in the way of fertilizing and cultivating this crop to get the highest returns.

No doubt certain market-garden crops can be profitably grown on the island for the New York market, and the station now has under way the development of this branch of agriculture. Arrangements have been made with the New York and Porto Rico Steamship Company to handle shipments of perishable fruits and vegetables expeditiously. The results, financial and otherwise, of trial shipments to the States will be published from time to time in the reports of the station and in the newspapers of the island.

Aside from horticultural and field products the island exports a great many horses and cattle. There is a great need, however, for the introduction of better blood, and it is to be hoped that the insular legislature at its forthcoming session will appropriate an amount sufficient to enable the station to equip itself with some blooded horses, cattle, pigs, and poultry. No doubt live stock of superior quality can be grown upon the island, and the native horses and cattle will lend themselves very readily to improvement by the introduction of pure-blooded stock.

The growing of rice needs investigation and encouragement. The small amount now grown upon the island indicates that it can be made profitable, and as this staple forms a considerable part of the food of the inhabitants its growth would stop the large importations now made.

Certain fiber crops would doubtless prove profitable for Porto Rico, especially the growing of Sea Island cotton. From reports received from various sections of the island the indications are that this plant will do well here if properly fertilized and cultivated. The station has under way experiments in growing Sea Island cotton, paying especial attention to the fertilization of the soil for this crop.

More forage crops, and especially the growing of legumes, are much to be desired. A number of legumes are under investigation, both at Mayaguez and the substation at "La Carmelita." At the latter place alfalfa and red clover are very promising, and at Mayaguez very good results have been obtained with velvet beans. By inoculating the various legumes with material obtained from the Bureau of Plant Industry the outlook with velvet beans, cowpeas, and other legumes is more promising than indicated in the last report.

One of the greatest problems confronting the agriculturist in Porto Rico is the proper fertilization of his crops, whether they be of the field, garden, or orchard. The continuous cropping of the soils for several hundred years has resulted in the great depletion of their fertility, especially as their culture is often accompanied by torrential rains that tend to wash away the surface soil in many places. The use of artificial fertilizers is comparatively recent in Porto Rico, and for the present extends to only a few of the more progressive sugar planters. Information upon the proper use of fertilizers is much to be desired, and at the same time a Territorial law covering the analysis and inspection of fertilizers sold in Porto Rico is highly important. This matter will be brought to the attention of the legislature at its coming session in urging the passage of an inspection law that will safeguard the planter and encourage the increased use of fertilizers. In this connection it will be necessary to provide for the services of a chemist, which is very much needed in the work of the station.

The station is cooperating with the public schools of Mayaguez in carrying out a system of school gardens, with the hope of interesting the coming generation in agricultural pursuits. It is important that in the scheme of education in the island attention be paid to certain practical affairs, of which agriculture is destined to remain chief. A school garden would be especially important because of the fact that while many of the people are extremely poor they fail to have gardens growing about their little houses, depending wholly upon nature to provide some of the necessaries of life that might be easily procured with a little labor. The station is endeavoring to encourage the planting of gardens by the men working in the various departments. Seeds and manures are furnished and every encouragement given them to plant gardens about their houses for their own good and as an example to their neighbors.

REPORT OF O. W. BARRETT, ENTOMOLOGIST AND BOTANIST.

During the past year the work was almost exclusively of a horticultural nature, but very few specimens have been added to the herbarium, and the entomological work was largely of an economic nature.

During July and August attention was directed largely to the preparation of the 25-acre orchard and the assembling of the 85 varieties

of fruits and economic trees in the nurseries. Planting of the orchard was begun in September and finished in December. A wind-break, composed of mamey (*Mammea americana*), guamá (*Inga vera*), mango (*Mangifera indica*), and rose apple (*Jambosa vulgaris*), was set on the east side of the experimental plats tract; volunteer 1-year-old seedlings were set 1 meter apart. The tea plants, of four varieties, were removed from the nursery and set 2 meters apart in a shallow rich soil, where they are now making a slow growth. From January to April the time was occupied in harvesting the experimental crops, preparing plats for new experiments, and planting same.

In March a special study was made of the brown, or stinging, ant (*Solenopsis geminata*), which was becoming exceedingly injurious in orange orchards in the Bayamon district, where it had destroyed trees to the value of several thousand dollars. The injury is caused by this ant, which is normally predaceous, acquiring the habit of attacking the bark at the base of the trunk and also the bud tips. By gnawing the bark in order to obtain the gummy excretion, which the insect delights to feed upon, sores are made in the trunk of the tree, which are gradually enlarged until the tree is nearly or quite girdled. An ant-killing mixture was devised for destroying the colonies in the ground, and a cheap girdle paint was also prepared to protect the decorticated and gum-exuding areas of the trunk and to prevent the passage of the ants up the tree. This killing mixture has been successfully used, but in some places is replaced by a strong kerosene emulsion. The girdle paint probably saved the lives of many trees by preventing the drying and cracking of the exposed wood.

A budding tape prepared with a certain grade of oilless paraffin from the match factories has proved very successful and costs much less than the ordinary beeswax-resin tape.

RESULTS OF WORK.

The stock of plants for distribution has been greatly increased with a view of more extensive exchange and gratis insular distribution. Especial attention has been directed toward the collections of bananas, yautias, cassavas, and yams.

Fertilizer experiments have been tried with yautias, cassava, and vegetables only, since the character of the soil in the 10-acre experimental plat is too variable to allow accurate results.

The domestic as well as foreign exchanges have been carefully attended to, with the result that many interesting economic plants have been acquired and distributed at only a slight expense. During the fiscal year over 50 packages of seeds, roots, and plants have been sent to planters on the island, while about 85 packages were received, including some 35 native and budded citrus varieties. Fourteen

varieties of plants, including 9 bananas, have been received from the Hawaii Station and 30 varieties have been sent. Over 100 packages have been sent to the States, and about 40 varieties of plants, exclusive of a large collection of grapes from the Bureau of Plant Industry, have been received in exchange. Over 40 varieties of economic plants have been sent to foreign exchanges and about 45 varieties have been received therefrom. The matter of exchanges is rapidly assuming importance, especially with Cuba and the British botanic stations in tropical America.

Perhaps the most important result of work during the year has been the discovery of a parasite (*Chrysocharis livida*) of the coffee leaf miner (*Leucoptera coffeella*). This parasite is doing much toward checking, if not exterminating, the leaf miner in some localities, and measures are being taken for its breeding at the station for distribution to plantations where not found.

The result of hand-picking of the infested leaves, which was begun during the previous fiscal year, was a complete failure, since the number of leaf miners was only slightly reduced in the coffee plat, containing 1,000 trees. Spraying infested plants was likewise found impracticable.

PLANT COLLECTIONS.

BANANA PLAT.

Only 6 varieties of bananas are in common cultivation in Porto Rico. To the 23 native and 22 foreign varieties assembled last year there have been added the following varieties:

From Florida, U. S. A.: Golden, Orinoco, Hart's Choice, Cavendishii, and Chue Chumpa.

From Allan's nurseries: One variety, probably Cavendishii.

From Santo Domingo: Johnson.

From Hawaii Experiment Station: Brazilian, Kapua, Hai, Apple, Maole, Hua Moa, Lele, Popoulu, Striped, and Ae-ae.

From Philippine Islands (through U. S. Department of Agriculture, Bureau of Plant Industry): Abacá (*Musa textilis*).

Through insular exchanges: Congo Manila, Maricongo, Niño, Tirabuzon, and Rosa.

From the Canary Islands, one variety, making the present number of named varieties 68.

Nearly all the native varieties and over half of the 22 varieties received from the Jamaica department of agriculture have fruited. Most of the latter have never fruited before in Porto Rico.

A permanent plat in alluvial soil near the office is being planted with five plants of each variety. This plat will be for display, as well as a secondary variety test under very much better conditions

than in the old plat, which is still retained for propagating sets for distribution.

Records are being kept of the prominent characters of the stem, leaf, and fruit of each variety. The average weight of the fruit and the percentage of pulp are also ascertained. Experiments in preparing flour, starch, and other products from the different sorts are being carried out with the view of finding varieties which are more palatable in the dried state than those now on the market.

YAUTIA COLLECTION.

A second variety test is being conducted with the 25 named varieties assembled last year (Pl. XVII, fig. 1), and of these it appears that about five names should be merged as synonyms. The localism of the yautia varieties in Porto Rico is a perplexing problem, which is being gradually worked out. The native varieties are being compared with those from the British West Indies, Guatemala, Belize, and Venezuela. No evidence has been secured of the existence of this valuable crop outside of tropical America previous to the distributions made by this station.

The following varieties have been added to the collection during the past year:

From Arecibo, Porto Rico: Dominica, Vino, Gengibrilla, and Quintal.

From Mayaguez vicinity: Samanal, Isleña, Brava, and Belembe.

From United States, through florists: Two varieties.

From Guatemala: Three varieties.

From Belize, British Honduras: One variety.

From Trinidad Botanic Gardens: Two varieties.

From Cidra, Porto Rico: Amadea, Luquillo, De Rio, Blanca, Martinica, Minas, and Amarilla.

Of the present 46 named varieties about 30 are distinct. At least five botanical species are represented—all of the genus Xanthosoma.

Ripe tubers have been successfully sent to Queensland, Australia, and to Singapore. Very favorable reports have been received from the varieties distributed to the Hawaii Experiment Station.

Analysis of the tubers of variety No. 1 (Rollisa) shows a starch content of 28.65 per cent. The central rhizome, or "madre," of this variety contains about 17.88 per cent of starch, with about 73 per cent of water. The starch grain is of medium size (about 0.01 mm.), and, since there is very little gummy matter, settling is rapid. A sample of this starch, which has been on exhibition in this office for nearly one year, has not deteriorated. It closely resembles cornstarch. There appears to be no reason why the manufacture of yautia, or tanier, starch should not prove very successful.

FIG. 1.—YAUTIA VARIETY PLATS, PORTO RICO STATION.

FIG. 2.—CASSAVA VARIETY PLATS, PORTO RICO STATION.

The following table shows the relative proportions of the plant parts of the principal types of the native taniers, or yautias:

Relative proportion of the plant parts of yautias.

Variety.	Weight of entire plant.	Weight of tubers.	Weight of root-stock.	Weight of leaves.	Weight of offsets.	Percentage of tubers.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
Rollisa	11	3.75	2.25	3.5	1.5	34
Vino	10.75	2.5	2	4.5	1.75	23
Martinica	11.5	2.5	1.25	6	1.75	22
Amarilla	15.5	1.5	2.5	7.25	4.25	10

Fertilizer experiments were carried out with plats of variety No. 1; small plats containing 20 square meters, and 50 plants were used. On account of the variable character of the soil and the heavy rains, unsatisfactory results were obtained and therefore the same experiment has been repeated, the results of which will be known about January, 1905. Chemical fertilizers, coffee pulp, stable manure, and guano were tried. The highest yield resulted from the use of about 30 tons of stable manure per acre; this gave edible tubers at the rate of about 16 tons per acre, while one of the check plats gave as low as 8 tons per acre. The highest yield per plant, 3.22 pounds, was in the plat receiving stable manure, while the lowest yield per plant in the check plats was 1.6 pounds.

An experiment was also carried on with a method of double-cropping practiced in Trinidad, British West Indies. By this method a second crop of tubers was obtained from the same plants left standing after the first ripe roots had been removed.

Three diseases of the yautia have been studied. About 15 varieties have flowered.

A bulletin on the yautias, or taniers, of Porto Rico, has been prepared. This is to supply the needed information regarding this exceedingly old, if not the oldest, cultivated crop, which is coming into prominence through at least three of its types as a starch plant and cheap food producer; moreover, on account of the deplorable confusion of the taros (*Colocasia* spp.) and the taniers (*Xanthosoma* spp.) which has continued until the last few years, it is almost impossible to obtain any reliable information regarding the latter crop in any work of reference thus far published.

CASSAVA COLLECTION.

This collection has been increased by the addition of 2 varieties from the United States, the "narrow-leaf" and the "broad-leaf," 1 variety from Mayaguez vicinity, and 1 from Ponce; 28 named varieties are under test.

A second variety test (Pl. XVII, fig. 2) has been started to complete the data on root characters, yield, stem and leaf colors, and habit, especially with reference to resistance to fungus diseases and the bud maggot. In the first test for quality the average weight of roots per hill ranged from 1 pound (No. 6) to 7½ pounds (No. 17); conditions, however, were very unfavorable.

A test of the six methods of planting is being made, and also a test of fertilizers with the six varieties which gave the best results during the past year.

Four varieties were analyzed for starch content by the Bureau of Chemistry, United States Department of Agriculture, with the following result: No. 1, 23.86 per cent; No. 9, 21.50 per cent; No. 11, 23.84 per cent, and No. 17, 31.69 per cent. Of these all but No. 17 were received from the Jamaica department of agriculture. No. 17, Ceiba, is one of our three best native varieties, being nearly resistant to the bud maggot as well as fungus diseases, and attains a height of 10 feet in ordinary soil.

A small percentage of the roots at cropping were affected at the base with a dry, black rot, and at the tips of a very few of the larger roots was found a form of soft, white rot. A white mycelial growth was noted on some roots. The bud maggot (*Lonchæa chalybea*) has proved very injurious, especially on young plants of the sweet varieties. The principal effect of this pest is to cause excessive branching (which, however, is considered by the natives essential to a good yield).

The other pests mentioned in the Annual Report for 1903 have been but little in evidence this year.

ORCHARD.

In November 2-year-old budded trees of the following 23 citrus varieties were received from the Allan nurseries, near San Juan: Parson Brown, Ruby, Jaffa, Mandarin, King, Dancy, Tangarine, Satsuma, Dulcissimo, Bessie, Enterprise Seedless, Hart Late, Majorca, Homosasa, Magnum Bonum, St. Michael Blood, Pineapple, Valencia Late, Washington Naval, Thompson Naval, Duncan Pomelo, Marsh Seedless Pomelo, Kumquat (2 varieties), and Lemon.

In December and again in February buds of the following varieties were received from Florida: Oneco, Tresca, Centennial, Foster, Early Oblong, Royal pomelo, Pernambuco pomelo, Genoa lemon, Corsica citron, and Sour Rangpur lime. These buds were set in both rough-lemon and sour-orange stock. About 20 varieties of native seedling oranges and grape fruits have been secured and budded into our nurseries.

Plants of *Citrus trifoliata* for stock were secured, both from Aguadilla, Porto Rico, and Florida, United States of America. A

good quantity of seedlings of sour orange, bitter-sweet orange, and native grape fruit have been raised for budding purposes. A few seedlings of a sweet native grape fruit have been grown. In all, about 60 citrus varieties are now growing in orchards and nurseries.

The following varieties of fruits and nuts have been added to the 70 varieties listed in the report for 1903:

From Florida: Guavas (3 varieties), Akee (*Cupania sapida*), Avocado pear (Black Mexican), *Phyllanthus emblica*, *Hovenia dulcis*, *Rheedia edulis*, and Mango (Black Jamaican).

From Atlanta, Ga.: *Asimina triloba*.

From Aguadilla, Porto Rico: Murta (*Eugenia* sp.).

From Plant Improvement Gardens, Santa Ana, Cal.: *Castanea vesca*, *Juglans regia*, *Juglans californica*, and *Juglans sieboldiana*.

Sugar palms (*Arenga saccharifera*) from seed received through the Bureau of Plant Industry, from Manila, P. I., have been set out.

From Bureau of Plant Industry: One collection grafted mangoes and one collection Mangosteen seedlings.

MISCELLANEOUS CROPS.

The following plants have been added to the collection:

From Arecibo: Jamaica sorrel (*Hibiscus sabdariffa*); Vegetable musk (*H. abelmoschus*).

From the United States: Jerusalem artichoke (*Helianthus tuberosus*).

From Hawaii: Japanese taro, Royal taro, one yam, and *Macadamia ternifolia*.

From Porto Rico: Apio (*Arracacia esculenta*), Granadillo (*Passiflora quadrangularis*), one variety melon, one variety tuna (*Opuntia* sp.), *Cereus triangularis*, and vegetables, several native varieties.

The "Panamá," or wild *Alocasia macrorhiza*, has been grown in comparison with a variety obtained in Caracas and is apparently superior to the latter, producing roots of 10 to 15 pounds weight in about twelve months. These roots are used for feeding swine.

Two packages of "Dasheen" (*Colocasia* sp.) from Trinidad, British West Indies, have proved nearly identical with the variety tested last year. Contrary to expectation this plant has proved very different and, in many respects, superior to our native "malanga" (*Colocasia antiquorum esculentum*); it produces tuberous offsets of a high quality, and in about six to eight months from time of planting the first tubers are ready for harvesting. Two to four pounds of roots per hill are produced in good soil, and some 10,000 to 15,000 plants may be set per acre.

The native Yam Bean (*Pachyrhizus tuberosus*) has exceeded expectations. Numerous roots weighing as high as 5 and even 7

pounds each were obtained without the use of fertilizer. Analysis shows the starch content to be nearly 15 per cent, with over 75 per cent of water; the cellulose is proportionately low and commercial starch extraction should be simple. A fertilized plat has been planted with this interesting crop. Seeds have been distributed to various localities of the island and to the foreign exchanges. It occurs wild in the virgin forest at the coffee substation.

The Teyote (*Sechium edule*) has proved a failure at the station grounds; two varieties were found, however, growing luxuriantly in the virgin forest at the coffee substation. It apparently requires rich soil, partial shade, and considerable moisture.

The *Centrosema plumieri*, brought from St. Vincent, has proved a valuable cover crop. Since it roots at the joints, one plant will quickly cover several hundred square feet, and as it lives for two seasons at least, it is hoped it will prove valuable in orchards having sandy soil.

The Venezuelan Apio (*Arracacia esculenta*) is thriving in a moist, partly shaded location. This important vegetable is grown to some slight extent in the interior districts.

The Costa Rican papaws have proved inferior to the native varieties in point of richness of flavor.

The two roots received from Hawaii Station as *Tacca pinnatifida* have continued to make an exceedingly heavy and healthy growth, but it is now evident that they belong to the genus Dioscorea (and are probably *D. pentaphylla*).

The native "malanga" (*Colocasia antiquorum esculentum*) has made a very strong, healthy growth. Analysis by the Bureau of Chemistry, U. S. Department of Agriculture, shows the mature roots to contain 14.94 per cent starch and 74.47 per cent moisture. But since the starch grain of this root is so very small and the gum content so high, extraction of the starch commercially would be quite difficult.

The two varieties of Hawaiian taro (*Colocasia* spp.) resemble in habit and flower the Trinidad varieties called "Dasheen," but the yields are much less. They appear to be free from the Hawaiian root disease thus far.

The edible canna (*Canna edulis*) has continued to make a good growth, and has remained almost free from attacks of either fungus or insect parasites. The yield was about 15 tons of roots per acre, the same as was obtained at Rio Piedras. These roots show a starch content of 19.41 per cent and 70.25 per cent water. The starch grain is very large and readily separable. Although this crop requires a moist, rich soil, it is quite possible that it may become an important starch producer of the future.

Coffea stenophylla, *C. robusta*, *C. liberica*, and some six varieties of

C. arabica have been received through the foreign exchanges and turned over to Mr. J. W. van Leenhoff, at the coffee substation.

FIBER PLANTS.

Bulbils of *Furcræa fœtida* have been received from Mauritius Island through the Bureau of Plant Industry. They have been planted out near the native variety in order to prove the supposed identity therewith. One plant of *Furcræa tuberosa*, from Central America, has been received.

Plants of the native maguey (*Furcræa fœtida*), which are now eighteen months old from the bulbil, have leaves 5 feet long, and are growing rapidly. The 2-year-old Bahama sisal plants have 3-foot leaves.

The Bahama sisal (*Agave rigida sisalina*) has made a fairly good growth and is now free from the bacterial disease with which it was affected during the previous year. Numerous offsets have been set out ready for distribution.

Twelve bulbils of a plant believed to be the true *Agave rigida* have been received from Sneads Island, Florida.

Seeds of *Bœhmeria nivea* have been received from the Bureau of Plant Industry.

Sansevieria zeylanica has been added to the collection.

Gossypium arboreum, from Mexico, is making a slow growth.

A plat of mixed cotton has done well. Several varieties are now being planted for a comparative test.

Specimens of ropes and cordage, prepared from various native plants at the coffee substation, have been secured for exhibition at the station office.

FOREST PLAT.

The following species have been added to the nurseries for this plat:

From Cabo Rojo, Beefwood (*Casuarina equisitefolia*). From Ponce, Rain-tree (*Pithecolobium saman*). From British Honduras, Broad-leaf Mahogany (*Swietenia macrophylla*). Through Bureau of Plant Industry, Chinese oil-nut (*Aleurites cordata*); Chinese oak (*Quercus cornea*); sugar palm (*Arenga saccharifera*); Talipot palm (*Corypha umbraculifera*).

From Curacao: "Cuji" and Divi-Divi (*Cæsalpinia coriaria*).

From British West India stations: "Madre de Cacao" (*Gliricidia maculata*), *Bauhinia* sp., and *Parkia africana.*

Through the United States Department of Agriculture, Bureau of Forestry: Hybrid *Eucalyptus* and *Grevillea robusta.*

From Plant Improvement Gardens, Santa Ana, Cal.: *Parkia roxburghii.*

Nearly all the varieties set out in 1902 are now making a fair growth; the *Eucalyptus* spp. especially have done very well, considering the exceedingly poor soil of the plat.

About 75 species of timber trees are under trial in this plantation; 100 square feet are allowed each tree.

INSECT PESTS.

The cotton stainer, *Dysdercus suturellus*, has caused considerable damage in a cotton field near Sabana Grande. *Aphis gossypii* has been reported from only one locality as a serious pest, but it undoubtedly occurs throughout the island. The coffee aphid occurs over a wide area, if not the entire interior of the island, but does no damage except to the tender shoots in overshaded localities. The malanga, or taro, aphid has been much less in evidence than during the previous year. *Pteromalus calandræ* in a common parasite of the rice weevil (*Calandra oryzæ*) at the station.

During the past year no complaint of the changa (*Scapteriscus didactylus*) has been received at this office. The grass Paris-green bait remedy, recommended in Bulletin No. 2 of the station, is being successfully used, not only in Porto Rico, but also in the British West Indies. The bug maggot (*Lonchæa chalybea*) of the cassava has continued a serious pest in the tips of cassava canes. Hand picking is the best remedy, though tobacco dust applied to the buds is effective in the dry season. The cassava tingitid (*Atheas nigricornis*) has been less destructive on cassava leaves than in the previous year.

The black-winged white ant (*Eutermes morio*) has been practically exterminated in the vicinity of the station buildings; burning with kerosene was found the most reliable method.

The striped weevil (*Exophthalmus spengleri*) continues in abundance in orange orchards throughout the island. Hand picking is commonly practiced, but merely serves to keep the pest in check. This weevil and a smaller species, closely related, are common in some coffee plantations where they do considerable injury to the buds and young leaves.

The tobacco leaf miner (*Gelechia picipellis*) did some slight damage in the experiment plats at Aguas Buenas.

Four species of Lamellicorn beetles attacked citrus and banana leaves on the north side of the island, doing more or less injury during the dry season. Hand collecting at night and the use of lime on the ground about the trunk appear successful in the Bayamon district. These beetles make numerous vertical burrows close to the base of the trunk and hide in these burrows during the daytime. It is thought that the larval stage is passed among the orange roots, though this has not yet been definitely proven.

It is estimated that the Tineid coffee leaf miner (*Leucoptera coffeella*), by checking the growth and destroying the leaf tissue of coffee plants throughout the island, resulted in from 5 to 10 per cent loss of last year's coffee crop. This would amount to from $150,000 to $300,000, taking into consideration merely the product of berries and not allowing for the damage to the vigor of the plant. Experiments in collecting by hand infested leaves from a certain number of isolated trees proved an entire failure; likewise spraying experiments have thus far proved ineffective in checking the ravages of this pest.

The coffee leaf miner, however, is on the decrease in several districts of the island, due very largely to the attack of a Chalcidid parasite (*Chrysocharis livida*) found in the coffee plats in the station grounds. The life history of this very beneficial insect is nearly worked out, but its method of oviposition is unknown. Larvæ of the parasite, however, have been found inside the bodies of Leucoptera larvæ, and it is believed that the egg is laid in or upon the half-grown larva of the leaf miner. On account of the numerous immature larvæ of the parasite found in empty burrows of the leaf miner, it appears that because of the abundance of the parasites the female frequently oviposits in larvæ that are too young to allow the complete development of the parasite, and that the parasitic larva, after having devoured its too small host, is left without food and probably dies in the burrow without reaching the pupal stage. Attempts to induce these starving parasites to feed upon Leucoptera larvæ have in all cases proved unsuccessful, even when the parasite has been partially introduced into the host larva. The full-sized larva of the parasite is about one-third the size of the host larva—that is, a little more than 1 millimeter in length. The pupal stage is normally passed inside the burrow of the leaf miner; the shining bluish black pupa is loosely attached by its posterior extremity to either the wall of the burrow or to the integument of the consumed host; one pupa was found in a cocoon of the host larva on the outside of the leaf. The imago is black with purplish reflections from the thorax; the size is about 1 millimeter; it is very active, and lives two to four days in captivity. It is doubtful whether living specimens of this parasite could be sent successfully to other islands in the West Indies where the leaf miner is a serious pest, unless, perhaps, in a Wardian case with its host, under more or less natural conditions.

FUNGOUS DISEASES.

Ascochyta nicotianæ, under two or three forms, caused considerable injury to the station's tobacco plats at Aguas Buenas.

A fungus belonging to the Sphæropsideæ has been very prevalent on

banana leaves, causing minute clustered dots, beginning on the under side and extending through to the upper surface, associated with a yellowing of the surrounding area. This attack usually precedes a gradual wilting of all the leaves of the plant, but may continue for months in an immature state. A rot, probably of bacterial origin, did considerable injury to bananas fertilized with nitrogenous manures; streaks of brownish tissue indicate the course of the disease from the root bulb to the top of the pseudostem. Destroying the affected plants apparently checks the trouble, though the suckers from the old bulb grow slowly.

The tomato wilt, which has been under investigation for over two years, has not yet been definitely determined, but it certainly resembles very closely in effect the *Bacillus solanacearum*. It appears to be common in the West Indies and prevents the successful cultivation of tomatoes in this region. Plants at the coffee substation, at about 1,000 feet elevation, showed only slight traces of the disease.

The American coffee disease (*Stilbum flavidum*) occurs very rarely.

A yellow-spot fungus, in effect resembling *Stilbum flavidum*, occurs on "rough lemon" leaves, and may become a serious pest in orange nurseries.

White mycelial growths have been noted on the roots of cassava, yautia, yam, and coffee. In the case of coffee this fungus was usually accompanied by more or less decay of the interior of the root. This mycelial disease of the yautia root seems to be distinct from *Peronospora trichotoma* of the taro.

A serious disease, called locally "el mal," attacks the fibro-vascular bundles of the rhizome of yautias, especially of *Xanthosoma sagittæfolia*, beginning at the tip and slowly spreading into the tubers and upward through the root stalk, finally causing the decay of the latter, and occasionally reaching the leaf bases. This fungous or bacterial disease apparently does not affect the vitality of the tubers when left in situ.

A peculiar leaf disease of the yautia occurs on the older leaves, causing roundish or somewhat irregular brownish patches, showing concentric rings of a darker shade; it is much more prevalent in the dry season. Samples of this fungus were determined as *Periconia pycnospora;* a *Glœosporium* sp. was also found in a sample sent for determination to the Bureau of Plant Industry.

A black-spored fungus occurring in roundish patches on the leaves of *Canna edulis* was determined as *Periconia* sp. The roots of *Canna edulis* appear completely resistant to all fungi.

Cladosporium citri continues to be a serious pest in citrus nurseries, on sour orange seedlings used for budding stock; it severely checks the growth of these seedlings so that the orange planter is compelled

to insert the sweet orange buds as early as possible—frequently when the stock is under 2 feet in height.

A disease apparently fungous in nature is becoming generally prevalent on the coffee leaf miner (*Leucoptera coffeella*) in its early larval stages. Cultures have been made with this material, but in only one case did a white mycelial growth indicate the fungous nature of this disease. The etiology of this very important disease of the most serious pest of Porto Rican coffee demands careful investigation. In the coffee plats at the station grounds about 30 per cent of the leaf miner larvæ are found dead in their burrows; at the coffee substation about 10 per cent, on an average, of dead larvæ are found.

The fungus, provisionally determined as a Sporotrichum by Prof. F. S. Earle, continues to be very plentiful on the red scale (*Lecanium hemisphæricum*) throughout the island, and it aids very largely in keeping this pest in check. Inoculation experiments have not proved successful thus far, probably on account of the sensitiveness of this fungus to a dry atmosphere.

The coffee leaf blight discovered in June, 1903, by Prof. F. S. Earle, and provisionally referred by him to the genus Sclerotium, is abundant in many districts in the west part of the island. In April, 1904, this disease was carefully studied at the station coffee plats by Dr. G. P. Clinton. This peculiar disease appears to attack the root system first, causing more or less decay therein, and thence ascends the trunk in the form of brownish or black mycelial threads. Upon these threads reaching the base of a leaf they begin to spread and frequently appear like a thick mass of cobweb. The base of the leaf at once turns dark brown, though the midrib and distal portion may remain green for some time. Upon the death of the leaf the petiole breaks away from the branch, but is held by the tough strands of the mycelium.

Specimens of a rare coffee leaf disease occurring in the vicinity of Arecibo have been determined as a *Sphæropsis* sp.

REPORT OF H. C. HENRICKSEN, ASSISTANT HORTICULTURIST.

The writer entered on duty at this station March 1 and took charge of the following lines of work, which were outlined in last year's report: Citrus fruits, pineapples, vegetables, cacao, miscellaneous fruit orchard, tea, and rubber.

The scope of work with all of these has been considerably broadened, and the following new experiments have been started: Grapes, mangoes, aguacates, and the propagation of miscellaneous tropical fruits.

CITRUS FRUITS.

The nursery contains about 3,000 trees, consisting of rough lemon and sour orange, with a few sweet and bitter-sweet oranges, as well as some pomeloes, limes, and sweet lemons. One lot of these were planted in the seed bed December, 1902, and transplanted into the nursery June, 1903. The trees not budded are now 7 to 8 feet high and are rapidly outgrowing their usefulness as budding stock. Another lot was transplanted June, 1904, and will be ready for budding this fall. Two weeks before the writer's arrival 114 trees were budded to 11 varieties introduced from Florida. Since then 176 trees have been budded to 16 varieties, of which most were selected from seedling trees on the island.

The citrus grove contains about 250 budded trees, consisting of 22 of the best named varieties of orange, pomelo, and lemon, as well as a few selected seedlings and a number of stock ready for budding. (Pl. XVIII, figs. 1 and 2.)

A bulletin on The Propagation and Marketing of Citrus Fruits in Porto Rico has been issued.

The work for the ensuing year will be to collect bud wood from the best native seedling trees and bud one or two dozen nursery stock with each variety. When large enough, five trees of each of these will be transplanted into the orchard and the rest distributed among the growers.

The grove will be cultivated and fertilized, and notes carefully kept in order to form an idea of the cost of orange growing in this locality. Different legumes will also be tried as soiling crops.

THE OUTLOOK FOR CITRUS CULTURE IN PORTO RICO.

Citrus fruits are not cultivated extensively except around San Juan and a few places between there and Arecibo, which may be attributed to three things—the proximity to San Juan, where all the steamers from the States land; the character of the soil, which closely resembles the Florida soil, and the fact that the pioneer nurserymen settled there. It could not be because of the natural fitness, as nearly all of the oranges exported come from the west end of the island, and it is admitted by the growers that there is a vast amount of land there which is as well fitted for oranges as that of the San Juan district.

The writer recently visited most of the groves at Bayamon and Rio Piedras and noted the following facts: Most of the groves are from 25 to 500 acres, none is over four years old, most of the grove managers are practical Florida men, and Florida methods are used.

Neither foot rot nor die back nor wither tip was noted, and neither

FIG. 1.—A PORTO RICO SEEDLING ORANGE.

FIG. 2.—A BUDDED POMELO TWO AND ONE-HALF YEARS AFTER PLANTING.

has been reported. As there are no budded trees over four years old, it would be rather early to look for blight, but as none has been noted in the old seedling groves it should not be anticipated. With all of the foregoing, as well as the white fly eliminated, the Florida grower ought to feel contented in Porto Rico. But every place has its drawbacks, and here it has so far been the purple scale (*Mytilaspis citricola*), which at present is doing enough damage to make up for the absence of all the rest. Some growers are spraying and feel disheartened because a few applications do not exterminate the scale. Others have gone to the extreme of cleaning the trees by hand, and still others have done nothing whatever.

In the groves where spraying has been followed persistently and intelligently the scale is kept within bounds, and no grower has reason for dissatisfaction when remembering that this pest has been fought in Florida and California nearly fifty years and is still at large.

In the groves cleaned by hand the trees were healthy when planted and are kept so by constant attention. As soon as the scale is noticed a careful man is detailed to look after that part of the work, and the trees are gone over every two weeks and all the scale that can be found is picked off with a knife blade or a small stick. This method is very successful while the trees are small, and is probably no more expensive than spraying.

The groves that have not been treated for scale are all dead or dying, with the exception of one that is located in a hummock not unlike the Indian River and Orange Bend hummocks in Florida. Here strips of natural growth are left all through the grove, as well as a great number of palms scattered among the orange trees. These trees provide both wind and protection and shade, and the air is humid and the temperature fairly uniform. This grove is four years old, it covers over 400 acres, and is without exception the best budded grove on the island. It is not free from scale, but the scale is heavily parasitized, and the conditions are favorable enough for the parasites to keep it in check. This has also been observed in other places where the natural conditions had not been interfered with and is well worth considering when locating a grove.

While the above gives a good illustration of the advantage of favorable conditions, a careful observer would not fail to note that real success has been attained only by the men who have devoted their whole attention to the subject. The old adage that "an ounce of prevention is better than a pound of cure" ought to be thoroughly memorized by every orange grower, and every mistake by others as well as his own should be put down as a "don't." Here are some that may head the column: Don't neglect to prepare your land before

planting. Don't plant scaly or sickly trees. Don't let your trees stand still, work and fertilize them in order to keep them growing. Don't leave a sickly tree; if it will not grow pull it up and plant another; in the plant world as well as the animal world there are a few individuals constitutionally weak—destroy them, it improves the race. Don't let a destructive enemy like scale get a foothold, but attend to individual cases in the beginning, as one infected tree will infect the whole grove. Don't leave everything to the inexperienced workman—you can not expect both brain and muscle for 40 cents a day.

The seedling trees in the many natural groves around Mayaguez are very healthy and bear a comparatively good grade of fruit. Most of the trees are nearly thornless, which is unusual for seedling trees. There are no budded groves on this end of the island over one year old, but in the few instances noted the trees are doing well.

As there is a vast amount of land on the island which is no doubt as well fitted for citrus culture as the groves already planted, and remembering that the export last year amounted to over 130,000 boxes, which was probably not more than half of the actual production, it will readily be seen that Porto Rico will soon have to be reckoned as one of the chief citrus-producing countries.

PINEAPPLES.

There are four varieties of pines commonly grown on the island, viz, Porto Rico, here called Cabezona; Sugar Loaf, here called Pan de Azucar; a dark-leaved plant here called Negrita or Mamey, and a small, dark-green, very spiney plant here called Caraqueña. None of these has so far been of commercial importance except the Cabezona. This is extensively planted 5 miles west of Lajas, where the formation is rocky, with hills ranging from 50 to 200 feet higher than the surrounding plain. (Pl. XIX, fig. 1.) The soil is a heavy loam, mixed with coarse broken rock. The plants are set 8 to 10 inches apart in rows 6 to 8 feet apart, running around the hill. Paths leading from the bottom to the summit are left at intervals, by which the fruit is brought down in baskets, which the natives carry on their heads, though the slopes are often very steep. The fruit varies in size from 3 to 25 pounds; most weigh over 5 pounds and few over 20 pounds. This year about 140,000 fruits were shipped by rail to Mayaguez and canned for export. (Pl. XIX, fig. 2.)

The pinery on the station grounds now contains 17 varieties and more are expected soon. The Cabezona has been planted extensively in order to show different methods of planting and to conduct fertilizer experiments, as well as some other experiments outlined, if time will permit.

FIG. 1.—MOUNTAIN SIDE PLANTED TO PINEAPPLES, PORTO RICO.

FIG. 2.—CANNING PINEAPPLES, MAYAGUEZ.

Some experiments were started in May in cooperation with the owner, F. I. Matthews, at Rincon, whose pinery is located near the ocean, in a soil consisting of a coral sand. The plants there suffer from some physiological derangement not met with in Florida.

VEGETABLES.

The last week in May 56 varieties, comprising 21 species of vegetable seeds, were planted. This, with slight variation, was repeated in June and will be repeated every 30 to 60 days until next spring. Of tomatoes 104 varieties have been planted in order to find, if possible, some that are resistant to blight and wilt. Extensive experiments with grafting tomatoes and eggplants on the different varieties of Solanum have also been started. Native vegetables and herbs will be grown and improved by selection.

CACAO.

A valley on the station grounds was planted in June, 1903, with 350 cacao seedlings, comprising 12 varieties. Of these 314 are alive and growing vigorously. No cultivation is done except hoeing around the trees, and on the hillside drawing the soil from above to below the trees, making a level place a few feet wide around each. The natural growth has been gradually cut out and cuttings of *Erythrina mycropteryx* and *Gliricidia maculata* have been planted in rows between the cacao. Some of these have made a growth of 10 feet in six months, but the majority do not root as easily as anticipated. Some work in propagation of cacao has been outlined for the coming year.

MISCELLANEOUS FRUIT ORCHARD.

At the beginning of March this orchard contained 224 plants, comprising 81 species and varieties of native and imported trees and shrubs. Only a few plants have been added this summer, but a number of species will be planted next November and the experiments will be entirely confined to fruit-bearing plants of economic value. In a collection of this kind each species and often each variety should receive individual attention, which, however, will be almost impossible with the present means at hand.

TEA.

The plat planted with tea contains the following varieties: Japanese, Anam, Dragons Pool, and Amoy. It was planted July, 1903, in some of the best soil on the station grounds, and the plants grew well and were well cared for, but they soon threw out a profusion of bloom, which was constantly removed under the botanist's direction.

March 1 the bushes averaged about 18 inches high and were very compactly branched. They were full of bloom, which was removed. About a month later, when again blooming, the bushes were heavily trimmed and a commercial fertilizer containing an excess of ammonia was applied. This, however, has not changed the behavior of the plants, as they are about the same size to-day. Plants of three of the varieties have been sent to the coffee station in the mountains.

RUBBER.

The following extracts are from notes made by the botanist of the station: January, 1903, 100 yearling seedlings of *Castilloa elastica* received from the United States Department of Agriculture were planted in nursery beds. In August these plants were transplanted into the permanent rubber grove situated in a valley on the station grounds. The ground, which bore signs of former cultivation, was overgrown with long grass, which was cut around the holes only. The holes were dug 1 foot deep, 14 feet apart each way, and top soil filled in around the roots. June, 1903, seeds of Castilloa were received from Costa Rica. These germinated well and grew rapidly and 100 were transplanted to the rubber grove in August, while 100 more were transplanted to a nursery from which distributions are being made. Seedlings of *Funtumea elastica* and cuttings of *Ficus populnea* were also planted. Since March 1 all the plants have been hoed three times and the circle gradually enlarged around the trees by cutting the grass, which has been applied as a mulch, and in May some of the trees were fertilized with one-half pound nitrate of soda to each tree. The trees now measure from 10 inches to 6 feet high and are looking healthy, but about a month ago they were yellow in color and showed the effect of the dry weather. The fertilized plat shows no increase in growth over the unfertilized, but in the bottom of the valley, where the soil is better and moister, the plants are much larger and thriftier than on the dry hillside. Some of the distributed trees are reported as doing well, but from present indications Castilloa should be planted only in rich moist soil.

GRAPES.

A number of grape cuttings received from the Bureau of Plant Industry of the U. S. Department of Agriculture were planted in a piece of ground wholly unfit for a cutting bed, but nothing else was available at the time. Many of the cuttings failed to root and the others made but slow progress. The most promising of the rooted cuttings were later transplanted to the permanent vineyard, which was located on a typical dry hillside having a tenacious red clay soil. This site was chosen on account of being accessible to an irrigation ditch.

Grapevines are found scatteringly on the island, but are not grown

commercially, which is said to be on account of the fact that the culture of grapes was prohibited under the Spanish rule.

As grapes are grown on other West Indian islands, the work which naturally suggests itself would be to select and plant such varieties as those succeeding under conditions similar to Porto Rico. However, the location of the experiment station is not one that would naturally be selected for a vineyard, and, if the means would allow, further experiments should be carried on at a higher altitude.

MANGOES.

The most promising fruit tree in the vicinity of Mayaguez is without exception the mango. The trees are conspicuous everywhere with their dark-green and wine-colored foliage. They are never cultivated, but may be found in waste places, and especially in old fence rows, where they were planted years ago as wind-breaks. Such valuable trees would be considered an asset nearly everywhere, but here their greatest value is in the amount of firewood they produce, the top being cut off every other year and used for fuel. This treatment does not seem to injure the trees, as a new top will be formed in a short time, but, of course, not much fruit is produced. The fruit is good, bad, or indifferent—mostly the last—but it might be safely stated that not many trees bear fruit of exactly the same quality, and there will, of course, never be demand enough for it to justify shipping. But if it can be demonstrated that these trees can be grafted or top budded they will be a source of income never dreamed of. Some experiments in that line have already been conducted, which will be continued until satisfactory results shall have been obtained. Twelve of the best varieties growing in India have been received as grafted plants from the U. S. Department of Agriculture. These have been inarched into large trees and may be expected to bear fruit in two years.

AGUACATES.

Like the mango, this fruit ought to be propagated asexually, as it does not come true to seed. It grows vigorously all over the island and a great amount of magnificent fruit is produced, which ought to be shipped to the States as it is fully equal to the Florida product, though it may be difficult to ship with the present facilities. But after a few years' selection and cultivation and with improved shipping facilities the aguacate will undoubtedly be one of the best paying fruits on the island. The initiatory steps have been taken toward propagating this fruit on a large scale and the coming year's work will include selection of the best varieties on the island as well as from abroad, which, when budded, will be distributed to the growers.

PROPAGATION OF MISCELLANEOUS TROPICAL FRUITS.

The ten foregoing subjects have been taken up first, not by any means because they are the most important, but because they come nearest to hand. The fact is that the Tropics possess so many unsolved horticultural problems that one is more likely to undertake too much than not enough, but it is much to be deplored that the propagation of a delicious fruit like the Ceriman (*Monstera deliciosa*) should be neglected just for the want of a few hours' time, or that the propagation of the fruit of all fruits, the mangosteen, should be delayed for another year simply for the want of a little more money. A hundred small seedlings of this tree were recently received from the U. S. Department of Agriculture, but unless time can be spared to bud, graft, or inarch it onto some allied species, of which there are some growing wild on the island, it will be many years before Porto Rico will produce mangosteens, and, in fact, it may never do so, as the tree may not succeed on its own roots in the Porto Rican soil.

The guava grows wild in Porto Rico—in fact it is a weed and is met with everywhere. In spite of this, the writer has not been able to obtain a fruit which a Floridian would call edible. Here is room for improvement.

The *Spondias dulcis*, a tree bearing a fruit nearly as large as an apple and of fine flavor, grows on the island, but is not very common because it is extremely difficult to propagate. If it could be grafted on hog plum, or Jobo (*Spondias lutea*), one of the most common trees of the island, or even on the Spanish plum (*Spondias purpurea*) it would be worth a great many thousand dollars to the island.

Many more of equal importance might be added.

REPORT OF J. W. VAN LEENHOFF, COFFEE SPECIALIST.

This year has been one of exceptional climatic conditions. The wet season, which as a rule ends about the middle of January, continued all through the months of February to April, and an especially heavy rainfall occurred during March. In consequence the blossoming of coffee, which occurs during these months, has been irregular, small, and damaged. It is estimated that the coffee crop will be only about from one-third to one-half of last year's crop.

Oranges, mangoes, and all other fruits have suffered even more, and minor fruits have in most cases given very poor results. As various other districts report similar conditions, it can be said that the whole interior of the island has suffered a crop failure.

The influence of the conditions upon our experiments has been that we can not show results of our work. Experiments with fertilizers

do not show any returns in larger quantities of berries, but only in a more luxurious foliage and the general finer condition of the trees. The same can be said of all other experiments made with the view of increasing the production per tree.

IMPROVEMENT OF OLD COFFEE GROVE.

The crop produced on each of the 10 acres was again ascertained. Besides, all the productive trees thereon were counted in order to make it possible to get at the figures of production per tree. The results, as shown by the crop of 1903, are given below.

Yield of coffee on experimental tract in 1903.

	Acre No.—										Total.	Average per acre.
	1.	2.	3.	4.	5.	6.	7.	8.[a]	9.	10.		
Ripe berries:												
In liters	923½	805	943½	1,418	224	311½	418	....	521	520	6,084½	676
In pounds	1,229	1,009	1,191½	1,985½	325	381	487½	....	708	669	7,985½	887
Coffee ready for market, in pounds	251	206	243	397	67	78	101	....	144	136	1,623	180⅓
Productive trees per acre	413	1,095	882	742	428	745	584	....	902	924	6,715	[b]746
Product per tree, in pounds	0.608	0.188	0.275	0.535	0.156	0.105	0.173	....	0.160	0.147	.....	0.261

[a] All coffee trees taken out and partly replanted. [b] Average per tree.

The same figures of the cost of production as last year were used, except the price of pulping, hulling, and drying, which was increased from 60 cents to 75 cents per 100 pounds, making the cost per 100 pounds for harvesting and marketing the coffee as follows:

Picking	$1.16
Pulping, hulling, and drying	.75
Transporting berries from field to factory	.10
Transporting to Ponce market	.25
Total per 100 pounds	2.26

After the harvesting the whole of the 10 acres was again carefully weeded and the trees pruned. The pruning consisted in the removal of all dead wood, the cutting down of all stumps that had lost their branches, excepting a few at the top, and the removal of all suckers. In some cases where stumps had lost many branches, but not sufficient to as yet cut them down, one or more suckers were allowed to remain so as to produce new stumps for the time when the old ones should be cut down.

The planting of leguminous plants between the coffee gave very good results as far as these plants themselves were concerned. After attaining maturity they were hoed under, but results to the coffee could not be obtained for the same reason as given for the fertilizers.

CUTTING COFFEE TREES TO STUMPS.

The trees in plats 9 and 10 cut to stump last year are doing well, in so far as they are not suffering from the attack of the leaf miner. The two shoots allowed to remain on each stump have now developed into trees about 6 feet high, which promise to be in bearing next year.

RENOVATING OLD COFFEE PLANTATION.

Plat No. 13 was found to consist of a thin layer of soil on top of rock, for which reason it was found not possible to cultivate it, and accordingly it was abandoned.

Plat No. 14 was planted with 164 coffee seedlings from nursery beds and 38 guaba seedlings for shade. All were cut on stump to 6 inches above the root collar, and are now doing very well.

Plat No. 15 was planted to alfalfa with the intention of using this as green manure by plowing it under, and then to plant coffee. The alfalfa, however, looked so promising that it was decided to allow it to stand, to reseed where necessary, and to continue experimenting with it in the hope that it might prove a valuable acquisition to the agricultural resources of the island of Porto Rico.

On plat No. 16, after the cowpeas planted last year were plowed under, plant holes were made and 190 coffee seedlings and 28 guaba seedlings for shade were planted in the same way as on plat No. 14. All are doing very well.

EXPERIMENTS WITH NEW PLANTINGS.

Fourteen acres of virgin forest land have now been cleared, laid out in fields, and partly planted. The clearing consisted of—

	Cost per acre.
Cutting away the underbrush, followed by felling the trees	$5.50
First burning (which destroyed all the smaller limbs and twigs), cutting and piling remaining timber, and final burning of piles	5.50
Total cost of clearing per acre	11.00

The very heavy timber, too heavy to be piled, was allowed to remain untouched. The soil thus prepared was lined and staked at distances of 7 by 7 feet, and according to these stakes a map showing the roads and different fields was made. Trails giving access to all fields have been made, and such small wooden bridges as were necessary were constructed. All plants set are doing well.

IMPROVEMENT IN PORTO RICAN COFFEE.

Coffee and shade trees have been planted for experiments with plant distances, as follows:

	No. of trees.
4 by 4 feet, eastern exposure	229
4 by 4 feet, western exposure	406
6 by 6 feet, western exposure	112
6 by 6 feet, eastern exposure	148
8 by 8 feet, eastern exposure	54
8 by 8 feet, western exposure	120
10 by 10 feet, eastern exposure	50
10 by 10 feet, western exposure	80
12 by 12 feet, eastern exposure	34
12 by 12 feet, western exposure	98
7 by 7 feet, exposed from all sides	334
7 by 7 feet, eastern exposure	191
Total Porto Rican coffee trees planted	1,856

This close planting has been used in order to find out whether it would be profitable to harvest from double the quantity of trees while they were small and to remove one-half for transplantation to another site as soon as the trees have become so developed that their branches touch each other.

For experiments with topping, crossbreeding, etc., land is in course of preparation and will soon be planted, for which 1,155 fine seedlings are ready in the nursery beds.

PLANTING OF FOREIGN COFFEE.

Owing to the difficulty of procuring foreign coffee and the loss of germinating power of coffee during long transportation, due in several cases to the poor preparation of the seed by shippers, it has not been possible to grow a representative collection of all coffees of different countries of the world. I regard it as of the highest importance to secure with the least possible loss of time all these different coffee varieties, so as to be able to select out of them the very best and most suitable to the American palate with which to improve our crop, either by direct planting or by crossbreeding. Thus far have been planted:

In fields:

70 Hawaiian trees, received from W. W. Brunner.

58 Ceylon hybrids, probably Maragogype and Ceylon seed, received from United States Department of Agriculture, Section of Seed and Plant Introduction, Washington, D. C., No. 8682.

10 Philippine trees, received from Mr. Bliss, ex-private secretary of governor of Porto Rico.

5 Haitian trees, received from officers of Dutch man-of-war *De Ruyter*.

In nursery beds:

4 Nuevo Café Pieraldi, received from Mr. Felipe Pieraldi, Yauco. This is probably a sport and similar to the many-seeded coffee received in 1873 by the botanical garden, Buitenzorg, Java, from Menado (Celebes).

In seed beds:

814 Alta Verapaz, Guatemala, received from Mr. José M. Valdés.
461 Maragogype, from Guatemala.
30 Caracolilla (?), from Guatemala.
30 Maragogype, from trees grown in Porto Rico.
180 Liberian, from Trinidad.
228 Abeokuta, from St. Lucia.
206 Mauritius.
221 Preanger, from Java.
192 Menado, from Java.
204 Padang, from Java.

Besides making experiments with coffee, which necessarily takes a long time before results are obtained, experiments with other plants have been undertaken which may give immediate results in improving the condition of the people living in the coffee regions and yield the planter profits between the coffee seasons. Also, experiments have been begun with such crops as may prove valuable additions to agriculture in the coffee regions in soils not occupied by coffee. For these objects the following have been planted: Bananas from the station at Mayaguez and other sources, 132 plants of 28 varieties; yautias, 177 plants of 12 varieties; tea, 19 plants of 3 varieties. There have also been planted besides trees suitable for shading coffee certain economic fruits, as oranges, lemons, and figs, and other trees, such as rubber, eucalyptus, etc. A number of varieties of yams and sweet potatoes are planted, and experiments are underway in cotton growing for the interior high lands of the island.

REPORT OF J. VAN LEENHOFF, TOBACCO EXPERT.

The information embodied in the first part of the following article was gathered during a trip of two months and a half through the island of Porto Rico from planters and manufacturers in the tobacco-growing districts of Aibonito, Cayey, Cidra, Caguas, Aguas Buenas, Comerio, Arecibo, Utuado, Yauco, and Jayuga, several days being spent in each district. Not only were investigations made into the local methods of growing tobacco, but typical tobacco samples were secured from each of the above districts for further study in the laboratory. Samples of typical soils and subsoils were obtained for chemical and physical examination.

In Porto Rico the seed bed is usually made on high inclined land and sometimes on level lands called "vegas." The high lands are, however, preferred, because they are more exempt from the depredations of insects. The preparation of the bed usually consists in

burning the ground and digging it up with a hoe, the time of preparation ranging from August 1 in some districts to September 1 in others. As a rule the seed bed is sown about the close of August. In order to have the plants ready for later setting out the bed is sown a second time from eight to fifteen days afterwards. In sowing, the seed is simply scattered over the bed, the quantity used being always exceedingly large in all districts. The seed is from plants of the second, or sucker, crop, and no seed selection whatever is done. In general, only a small percentage of seed reaches germination, which takes place from eight to twelve days after sowing. It requires from forty-five to sixty days for the plants to reach a size suitable for transplanting, at which time they have about eight leaves. The plants are usually left too long in the seed bed, so that they are too large for transplanting, due to the increased evaporation on the enlarged surface of the leaves.

The land is plowed in July and August and the native wooden plow is generally used, as only a very few planters have modern American steel plows. In fact, the agricultural tools and implements of all kinds are of the most primitive nature. The field is again plowed in October and gone over with a hoe, some planters using a harrow. Planting is usually begun in November. The distance between the plants in the row varies from 12 to 18 inches and the rows are from 20 to 36 inches apart. Not a single instance is known where tobacco is planted with the special object of raising wrapper or filler. The natives are very careless in getting the roots of the plants straight in the earth, and the writer has often seen seed plants set out with the tap roots doubled upon themselves. The young plants are pulled out of the seed bed by hand, often without any rootlets and frequently with the tap roots broken off. In setting out the seed plant the usual method is to take the plant in the left hand and to place it in a horizontal position in the hole prepared by one stroke of a hoe. A piece of hard earth is then pressed on the roots. The land is generally cultivated and hoed too deeply, the natives seeming not to have any fear of injuring the roots.

Topping generally takes place from forty to sixty days after transplanting, and consists in pinching off the terminal bud and leaving the required number of leaves on the stalk. Porto Rican tobacco is in most cases topped too low. The object of low and early topping is to obtain larger and heavier leaves. This practice of low topping and late harvesting is attributable to the fact that during the Spanish régime, prior to 1898, the market demanded a dark, heavy leaf, containing a large amount of nicotine. The American market, on the contrary, which now uses the greater part of the Porto Rican tobacco, calls for a light, thin, mild leaf. Accordingly the system of harvesting should be changed in order to meet the

new demands. After topping, many planters weed and cultivate again.

The leaves begin to ripen from thirty to forty days after topping, which may be noticed by their turning somewhat yellow. In this condition it is cut close to the ground. The plants are usually overripe when cut. After cutting they are laid on the ground until slightly wilted before being taken to the curing shed, the usual practice being to take a bundle of five plants or more in each hand or to bind a larger number on a pole which is then carried on the shoulder. Naturally a number of plants are permanently injured by this careless manner of carrying the tobacco.

The plants are hung together the first day and then separated. Very few Porto Rican planters follow the Cuban system of harvesting, which consists in cutting the leaves from the top down in pairs and hanging them across the arm. When ten or more pairs have been hung in this manner they are slipped off on a pole of about 4 yards in length and taken to the curing shed. After the tobacco has been cut earth is thrown over the stubble, in preparation for the second crop. Sometimes this process is repeated for the third crop. Very little care is taken with the second or third crops, which are, in fact, of rather inferior quality.

No attention is paid to the question of protecting the young plants from insects and diseases peculiar to them, which are much the same as those attacking tobacco plants in the United States. To guard the young plants against the ravages of the changa or mole cricket, it is a common practice to wrap a leaf of the mamey or mango around the stem when the plant is first set in the field, allowing the upper edge of the leaf to project above the ground. The use of Paris green, Bordeaux mixture, or other poisonous remedies is unknown.

The tobacco shed is a very primitive affair in most sections, consisting of a wooden frame thatched with straw and the sides covered with the same material or palm leaf to shelter the tobacco from the elements. The shed varies in size from 36 to 120 feet in length. No attention is paid to ventilation or to the situation of the curing shed with reference to sun, wind, or rain. No openings are provided to admit moist or dry air. Tobacco is very often seen hanging in stables and rooms of houses. Sheds with sides completely open are frequently used. It is the usual custom to leave the tobacco hanging in the shed twenty-one days. The plants are then placed between green plantain leaves in piles without removing the leaves from the stalks, and they are allowed to remain from one to seven days in this position, according to the locality and circumstances, with the object of producing the first fermentation and making the tobacco moist enough to strip. After stripping or removing the leaves from the stalks they are separated into different classes called

" capas," " tripas y capas," " tripas," and " boliches "—i. e., wrappers, fillers and wrappers, fillers, and bottom or sand leaves. They are then tied into bundles.

Fermenting is done in wooden boxes and occupies a period of about three months, after which a further classification is made, the leaves being then tied into hands and baled. Porto Rican tobacco is not, as a rule, sweated enough, and, as a consequence, many of the cigars made from it have a green and acrid taste. Some planters hang the tobacco plants 45 inches apart, leaving them from twenty-two to forty days. The leaves are then stripped from the stalks and sometimes separated into top, middle, and bottom leaves. Hands are made of from 80 to 100 leaves and these placed in round piles from one-half yard to 2 yards in height and 2 yards in diameter. Green plantain leaves are placed under each pile and the whole covered with them. The temperature is ascertained by merely inserting the hand into the pile, which remains in this condition from ten to twelve days, after which the tobacco is kept in wooden boxes for about fifteen days. When taken from these boxes it is classified into wrapper, filler, and wrappers and fillers. After classification it is wrapped in green plantain leaves and again placed in boxes. In from thirty to sixty days the tobacco is ready for use. Still other methods are in use, one of the most common being to make piles from 2,000 to 5,000 pounds in weight. After standing from six to eight days these piles are torn down and rebuilt. After another period of eight days they are again rebuilt in somewhat larger piles and are allowed to stand one or two months, after which they are ready for baling. Many merchants sweat them over again for about one month, after which the leaves are classified into—

Wrappers—first, second, and third sizes—light and dark.
Fillers—first, second, and third sizes—light and dark.

Some planters endeavor to secure light colors by making their fermenting piles long and very narrow, being only two hands wide, thus preventing as much as possible a rising temperature. This method retains the light colors, but results in little or no fermentation, thus rendering the tobacco unsuited for the market on account of its green and bitter taste. In this condition the tobacco can not be safely placed in the warehouse.

Porto Rican tobacco seed is always grown from the second or what is commonly called the " sucker " crop. No special care is taken with the seed-producing plants, all the plants in the field being allowed to produce seed. The seed, good and bad, after ripening, is harvested together. A large part of this seed does not germinate, and that capable of germination is in great measure from degenerated plants and produces seed plants having many undesirable qualities.

This practice explains the large amount of seed needed for a small area of seed bed. Such plants, furthermore, produce plants lacking in vigor, and this explains the fact that planters repeatedly have to reset plants in the field. As a result of this method, many tobacco fields produce a large number of leaves of all kinds, sizes, and shapes, which are wholly unfit for any practical purpose. Irrigation is extremely rare in Porto Rico, though droughts frequently occur and depreciate or destroy the tobacco crop. It is believed that where conditions are favorable money expended in irrigation would prove a profitable investment. Drainage is employed in a few localities only, the usual practice in the hilly lands being to dig ditches above the tobacco, and thus divert the water and prevent the overflow of the fields. In the level lands the drainage methods, as now practiced, could be very much improved. In many parts of the island severe losses were sustained during 1903–4 from the presence of standing water in the fields. Two seasons before the weather was quite dry, and the tobacco crop suffered from drought. This shows beyond a doubt the necessity for providing both drainage and irrigation in order to guard against unfavorable climatic conditions.

Inspection of samples of tobacco soils at the time they were taken showed that, as a rule, their texture was too heavy, as compared with similar samples of typical tobacco soils in the United States, for the production of a high-grade cigar tobacco, a fact brought out by the inspection of the following table, furnished by the Bureau of Soils of the Department of Agriculture:

Mechanical analyses of soils and subsoils from typical tobacco fields in several of the principal tobacco-growing districts of Porto Rico.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9372	(1) 8 kilometers NW. of Aibonito.	Valley "La Plata," soil, 0–10 inches.	5.97	3.24	6.02	4.20	12.64	10.04	31.72	31.98
9373	(2) 8 kilometers NW. of Aibonito.	Valley "La Plata," soil, 0–12 inches.	3.75	6.68	7.28	2.72	4.94	7.20	37.28	33.70
9374	(3) ¾ kilometer SE. of Cayey.	Gravelly sandy loam, 0–10 inches.	4.35	10.86	12.82	5.68	10.18	7.96	25.82	26.68
9375	(4) ¾ kilometer SE. of Cayey.	Brown stony loam, 10–20 inches.	2.37	6.06	10.24	4.50	7.80	9.88	31.84	29.54
9376	(5) ¾ kilometer SE. of Cayey.	Brown sandy soil, 0–12 inches.	1.33	.52	3.16	3.62	15.14	18.02	33.36	26.18
9377	(6) ¾ kilometer SE. of Cayey.	Subsoil of 9376, 12–20 inches.	.78	.84	4.30	4.32	15.22	17.80	32.38	25.14
9378	(7) 3 kilometers SW. of Cidra.	Dark sandy loam, 0–12 inches.	1.85	1.72	4.70	3.60	11.18	8.94	38.50	31.20
9379	(8) 3 kilometers NE. of Comerio.	----do ----------	2.53	4.98	9.10	5.20	11.46	8.36	32.96	27.66

Mechanical analyses of soils and subsoils from typical tobacco fields in several of the principal tobacco-growing districts of Porto Rico—Continued.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9380	(9) 4 miles SE. of Caguas.	Brown sandy loam, 0-10 inches.	1.44	5.30	8.26	5.22	11.10	11.32	32.40	25.80
9381	(10) 4 miles SE. of Caguas.	Subsoil of 9380, 10-20 inches.	1.36	5.80	6.54	4.28	10.12	10.40	33.54	28.96
9382	(11) Caguas	Brown sandy loam, 0-10 inches.	1.29	6.22	14.98	9.50	21.92	11.50	15.36	14.34
9383	(12) Caguas	Subsoil of 9383, 10-20 inches.	.82	2.42	5.96	3.50	8.02	10.76	42.64	26.70
9384	(13) ⅝ kilometer E. of Aguas Buenas.	Dark loam, 0-10 inches.	2.11	3.68	7.16	4.42	8.62	8.46	41.62	25.98
9385	(14) ⅝ kilometer E. of Aguas Buenas.	Yellow loam, 10-20 inches.	1.07	1.80	4.90	4.24	10.28	9.80	43.24	25.74
9386	(15) ⅝ kilometer E. of Aguas Buenas.	do	1.25	3.20	6.36	4.06	7.76	8.96	44.90	24.68
9387	(16) ⅝ kilometer E. of Arecibo.	Fine sand, 0-12 inches.	.59	.04	.50	4.32	53.32	22.94	11.72	6.98
9388	(17) Jayuya	Sandy loam, 0-10 inches.	3.19	3.16	5.30	3.04	7.46	9.52	45.82	25.56
9389	(18) 1 kilometer from Jayuya.	do	2.08	7.22	16.60	8.48	17.60	11.14	15.10	23.58

It will be seen that with but two exceptions the percentages of clay and silt are too high. Under the old régime of tobacco production in Porto Rico the fact that the tobaccos produced have, as a rule, been rather coarse, dark in color, and too heavy to meet the demands of the United States markets is attributable to the heavy texture of the soil. By improved methods of topping, harvesting, curing, and fermenting it has been observed that in this tropical climate a higher grade of cigar tobacco is produced. Experiments by the American Tobacco Company at Aibonito with soils that contained 31.98 per cent and 33.70 per cent of clay have shown that it is possible, through the shading of the tobacco with cloth, the application of fertilizers, and the use of improved methods of harvesting, curing, and fermenting, to produce tobacco yielding a high percentage of excellent wrapper leaves possessing good qualities as to elasticity, lighter colors, fine texture, and fair combustibility. In general, the Porto Rico tobacco leaves have too heavy veins and too thin body when grown under shade, and experiments in breeding and selection are greatly needed to secure a type of tobacco better adapted to use as wrappers. In this connection it may be said that the climatic conditions in the Tropics seem to be more favorable to the production of high-grade tobacco than in any of the more northern latitudes.

As a result of the above preliminary investigation is was concluded that Porto Rico presents very favorable conditions for the production of high-grade tobacco if localities are chosen with suitable soil areas and favorable climatic environments. Investigation also shows that for the most part the methods employed by the planters are primitive and that there is great need of their adopting more up-to-date methods. It was decided, therefore, to undertake experiments in growing, curing, and fermenting tobacco, but owing to the limited funds available for the work it was necessary to arrange for cooperation with an interested tobacco grower. Such an arrangement was made with a planter near Aguas Buenas, under which he furnished the land, labor, buildings, and material, in so far as this did not interfere with his regular business. The facilities offered, however, by the equipment of the ordinary planters are at the best unsatisfactory in many ways for experimental purposes, and because the funds available would not permit the necessary modifications of these conditions some of the experiments undertaken failed.

RESULTS OF EXPERIMENTS.

EFFECT OF SHADE IN THE SEED BED.

Several seed beds were constructed for experimental purposes, the sides being supported by old boards or poles. (Pl. XX.) Half of each shed was shaded by a movable straw shade, the other half remaining without shade. The shade was supported in an inclined position about 4 feet above the beds. The advantage of the shade lies in reducing the evaporation, and thus enabling the seed to germinate quicker and more perfectly; it furthermore protects the beds from washing by heavy rains. It often happens, as it did in 1903, that many seed beds are destroyed by heavy rains either by carrying away the seeds before they germinate or by washing out the plants when quite small. Records showed that the seed in the shaded portion of the beds came up several days earlier than in the unshaded portion. After the plants were all well grown the straw shade was removed for a short time each day early in the morning and late in the afternoon. The time of exposure was gradually increased and eventually the plants were shaded only from 10 a. m. to 3 p. m. A few days before transplanting in the fields the shade was removed and the plants exposed throughout the day. One portion of the shade was allowed to remain, and it was observed that while the plants in the shaded portion of the beds came up earlier and looked healthier during the first weeks, after that time those without shade appeared better, grew faster, and were finer, more vigorous, and larger. The plants under permanent shade did not thrive so well, owing to the lack

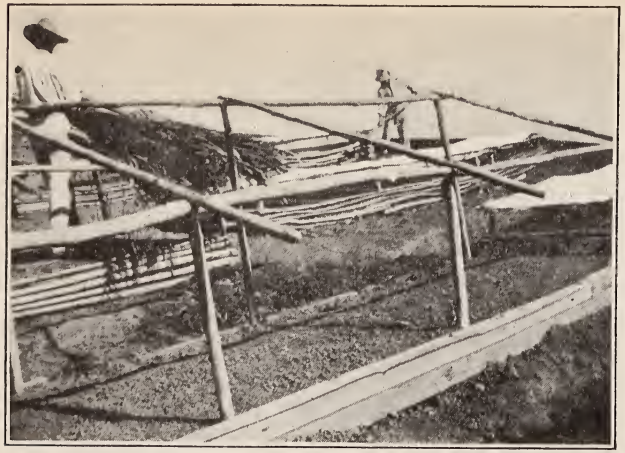

FIG. 1.—CONSTRUCTING STRAW SHADE FOR SEED BEDS, PORTO RICO.

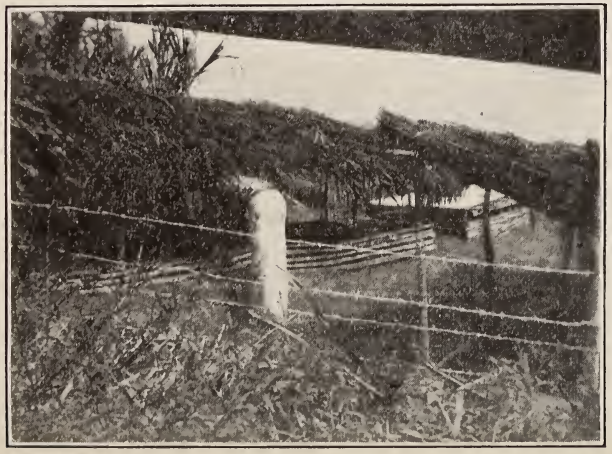

FIG. 2.—TOBACCO-SEED BEDS PROTECTED BY STRAW SHADE, PORTO RICO.

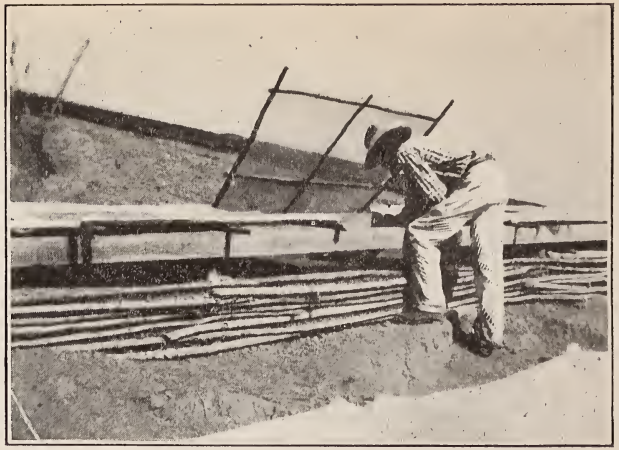

FIG. 3.—TOBACCO-SEED BEDS PROTECTED BY CLOTH COVERING, PORTO RICO.

FIG. 4.—CLOTH AND STRAW AS COVERING FOR SEED BEDS, PORTO RICO.

An. Rpt. Office of Experiment Stations, 1904.

of sunlight. The conclusion drawn from the above experiments is that shade in the first stages of growth is beneficial, but that day by day, as the plants grow, the time of exposure to the sun should be longer, until when they have reached the size for setting out the shade shall have been entirely removed. This process toughens the plants and enables them to stand the sun better when they are finally transplanted.

Cloth shade was also tried, and seemed to serve equally as well as the straw, the first being less dense than the latter. While it allowed most of the rain to pass through, it served as a regulator by breaking the fall of the rain, thus preventing washing away. It is believed that straw shade offers sufficient protection against the washing of the seed beds to alone justify its adoption, and that in practice it would be well to dispense with it as soon as the plants are well established and all danger from washing away is passed. Another seed bed was divided into five plats, each covered with a different colored cloth, the colors being white, blue, green, yellow, and red. This was to test the effect of the color of shade on the tobacco plant. These experiments might have given some data of value in the growing of tobacco seed under cloth, but, unfortunately, the seed used on these plats was imported Habana, and only a few plants were secured.

It is deemed very advisable to place the seed bed in Porto Rico, as is done in other countries, on low lands in preference to high, inclined lands, and in such proximity to the house of the planter as to make it convenient for him to give it all the attention possible, as, for example, to see that the seed bed is always kept moist.

EFFECT OF SHADE IN TRANSPLANTING.

Leaves of mamey and mango, common in Porto Rico, were used as a shade for the young transplanted plants by inserting the petiole in the ground and inclining the top of the leaf toward the plant. This shielded it from the direct rays of the sun during the hottest part of the day and has proved in general very satisfactory. The same method is followed in Sumatra—small, thin, petal-shaped boards being used instead of leaves. A trial was also made to ascertain the effect of mamey leaves as a protection against cutworms and mole crickets. The leaves were fashioned into cylinders, with the edges slightly overlapping, and placed in the ground with the roots and stems of the plants inside. Care should be taken to place the leaf no deeper in the soil than is necessary to prevent the crickets from boring beneath. While the mamey leaves make adequate barriers against the crickets, they are probably somewhat detrimental

to the early growth of the plants, because they confine the upper roots, and also because water from rain collected within the leaves escapes very slowly, sometimes injuring the plants. Experience has shown, however, that wrapping with this leaf is advisable. It has been found that by carefully placing the roots in the soil and watering when dry it is possible to improve very much upon the native methods of planting tobacco.

EXPERIMENTS WITH HALF AN ACRE OF TOBACCO GROWN UNDER SHADE.

It was planned to make a careful comparison of the cost of production of shade tobacco with that grown outside under otherwise the same conditions. Four-elevenths of an acre were planted under shade, and about the same date 2 acres outside. Very heavy rains occurred just after planting the outside tobacco, and a large part of the first planting was washed out. The delay in replanting and other uncontrollable factors interfered to such an extent with the outside crop that it was not worth while to carry out the comparison. The shade-grown tobacco was carefully cultivated, however, and an accurate record kept of it. Owing to the delay in getting the curing shed ready for this tobacco it was harvested in an overripe condition, and for this reason many of the bottom leaves were lost. A short time before the leaves began to ripen a disease appeared which gave rise to numerous whitish and brown spots. It spread very rapidly, and at the time of harvesting nearly all the leaves were affected, and many of them were so badly damaged as to make them useless for wrapper purposes. Some of the diseased leaves were sent to the U. S. Department of Agriculture for examination, and the Pathologist reported as follows:

> The leaves appear badly affected with the fungus *Ascochyta nicotianæ*. To the best of my opinion this fungus has not as yet been found within the limits of the United States proper, and we never heard of its previous occurrence in Porto Rico. In past years several reports of its occurrence have been made from various points in Italy. These reports, however, have been very meager, and we know very little concerning its destructive nature and practically nothing concerning methods of control. Judging from the specimens of leaves submitted it would appear to be a rather serious disease, and great care should be taken to prevent its spreading into other places.

It is quite possible that judicious fertilizing would increase the vigor of the plants and render them less susceptible to the disease. The use of a fertilizer containing a rather large percentage of potash is strongly recommended. If the soil be soggy, careful attention should be given to drainage. Diseased leaves and all leaves from a diseased crop should be burned. The approximate cost of the production of four-elevenths of an acre of shade tobacco was $250. In

spite of the unfavorable conditions there were 182 pounds of wrapper and 105 pounds of filler and binder raised—287 pounds, which makes 789 pounds to the acre. The value was $296, which gives a profit of $46 for four-elevenths of an acre, or $126.50 per acre, notwithstanding the unfavorable conditions. In the previous season almost the same kind of an experiment was made by the writer in the vicinity of Jayuya on two-thirteenths of an acre. There were 171 pounds of wrappers, 36 pounds of binders, and 21 pounds of filler raised, making 228 pounds in all. This gives a yield per acre of 1,482 pounds. Samples of the light and medium wrappers were valued by the cigar factories at San Juan at $2.50 and $2, respectively, and one large factory offered $1.50 per pound on the average.

As a result of these experiments and observations in regard to larger areas that have been grown under shade in Porto Rico it may be safely said that shading increases the yield, quality, and percentage of wrappers sufficiently to make it profitable, provided it is practiced only on soils suitable for growing wrappers and the crop is given the best of care throughout the growth and the same good treatment in the curing shed.

EXPERIMENTS WITH FERTILIZERS.

An experiment in fertilizing was carried on as an example of what any planter may easily try for himself. Sulphate of potash, acid phosphate, nitrate of soda, and lime were used for this purpose on a farm between Aibonito and Cayey. So far as the experiment was carried it indicates that the proper fertilizer for tobacco on this field is one containing a large amount of acid phosphate and a small amount of nitrogen and potash.

According to analyses reported by R. J. Davidson, of the Virginia Agricultural Experiment Station, the entire plants of a tobacco crop yielding 1,000 pounds of leaves per acre contain 66.85 pounds of nitrogen, 8.68 pounds of phosphoric acid, and 85.41 pounds of potash. The leaves of such a crop contain 44 pounds of nitrogen, 5.89 pounds of phosphoric acid, and 58.19 pounds of potash. The parts usually removed from the soil—the leaves and stalks—contain 58.9 pounds of nitrogen, 7.72 pounds of phosphoric acid, and 77.86 pounds of potash.[a]

This shows that the larger part of the fertilizing constituents is found in the leaves and stalks, and emphasizes the exacting character of the demands of the tobacco plant on the soil and the importance of returning to the soil all of the stalks and roots. This is a very important point for the Porto Rican planter, as in several places it was noticed that planters in preparing ground for future crops had thrown out of the field all the roots and stalks of the tobacco, a prac-

[a] Virginia Sta. Buls. 14 and 50.

tice that would not have been permitted had they appreciated their value. It was also noticed that beans were harvested by cutting and removing the whole plant from the field. As this crop belongs to the leguminous family and through the agency of the tubercles on its roots has the power of taking free nitrogen from the air, becoming itself richer in this element, the vines and all unused parts of the plant should be returned to the soil. This will also increase the thinness and elasticity of the tobacco leaf as well as improve the combustibility.

CURING EXPERIMENT.

A curing experiment carried on on a small scale seemed to indicate that a slightly lower temperature and higher relative humidity would give the best results. It was found that tobacco cured with an average temperature of 77.67° F. and with a relative humidity of 73.57 per cent was more desirable than that cured with an average temperature of 80.21° and a relative humidity of 68.30 per cent. These experiments showed the impossibility of fermenting large quantities of tobacco properly without a fermenting house so constructed that it could be hermetically closed in case of necessity, and in which the temperature and air moisture can be regulated.

SEED-SELECTION EXPERIMENT.

An examination of the tobacco fields of Porto Rico shows that there are practically no two plants alike, so that there can not be any distinctive Porto Rican type. This, it is believed, is the result of the ignorance of the value of seed selection. In the course of these experiments cooperation was entered into with the Plant Breeding Laboratory, U. S. Department of Agriculture, and eighteen selections and crosses were secured for planting in 1903 and 1904. One set was planted at Aguas Buenas and the other at Aibonito, but the last named was destroyed by the leaf miner or splitworm. At Aguas Buenas the selections throve very well, and from them the best and most uniform plants were selected, only thirty or forty capsules being left on the main flower stalks. These were covered with manila-paper bags to prevent cross fertilization. Seeds of the selections have been saved for further work along this line. This will undoubtedly be the beginning of a great improvement in the uniformity of Porto Rican tobacco planting, and it is believed that by this process strains can be bred for special qualities—as, for example, increased yield, more desirable shape, finer texture, etc.

The texture and structure of the soil, as has already been pointed out, have a great influence on the character of the tobacco produced. Soils light in texture—that is, having a relatively large amount of

sand and a small amount of clay—are best suited to the production of wrapper tobacco, and give leaves of medium size, fine texture, and good color. Filler crops may be grown to better advantage on a heavier soil. The character of subsoils is also important. A sandy soil and a low rainfall without irrigation should be underlaid at a depth of 1½ to 2 feet by a somewhat stiff subsoil, otherwise the plants will suffer from rot. On the contrary, if the rainfall be abundant a very porous subsoil will give the best results, because of the drainage which it affords.

TIME OF TRANSPLANTING FOR WRAPPER AND FILLER.

In Porto Rico the best season for planting tobacco seems to be in the winter, which is also true of Cuba. The rainfall at that season is less and the temperature several degrees cooler than in summer. Under the influence of the greater warmth and moisture of the summer the plants grow more rapidly, but the leaves do not acquire the desirable aroma they have when grown during the period in which less humidity and plenty of sunshine prevail. When grown in the summer, there is also danger from loss by standing water in the fields. Diseases are more prevalent at that time and leaves contain more nicotine. It is very important to gauge the time of planting so as to avoid excessive rainfall and extreme drought during the growing season, and also to have the harvesting and curing period occur in comparatively dry weather. Generally the best time for transplanting the wrapper tobacco seems to be about the end of October or the beginning of November. This brings harvest time about February 1, and gives that month and March, which are on the average the driest of the year, for curing. This also avoids serious damage by the flea-beetle, which is most prevalent during the dry season. Study of the Weather Bureau tables for Porto Rico shows that on the average November is a month of high rainfall, but that during the months of December, January, and February it rapidly decreases. If, therefore, a level, poorly drained land is to be used for the wrapper crop there is danger of its being damaged and sometimes destroyed by wet weather. In such cases it is advisable to defer planting until December.

For the filler crop it is advisable to plant about the middle or close of December, so that the principal growth will be made during the drier weather of February and March and the resulting slower growth develop a finer aroma. Care and thorough cultivation should be given the tobacco fields during the early growth of the plants. During dry weather the surface of the soil should be frequently stirred in order to destroy capillarity, thereby reducing evaporation directly from the soil and conserving the soil moisture for the use of

the plants. Any dry blanket that can be placed between the atmosphere and the damp soil will check this evaporation. The most practical protection is a covering of finely pulverized dry soil 2 or 3 inches deep. Surface cultivation not only reduces the loss of water from the soil, but also prevents the accumulation of the soluble plant food immediately at the surface, where it is out of reach of the plant roots. Cultivation should not be too deep, especially near the plants, as it destroys many of the small roots, thus lessening the feeding power of the plants. It also facilitates the formation of nitrates. Cultivation should not be undertaken when the soil is too wet. Stirring the soil in such a condition gives it a bad physical condition. If bad weather be continuous, all weeds should be removed with as little cultivation as possible. During the process of cultivation the soil should gradually be worked toward the plants, thus hilling them up and preventing them being blown down by wind.

For wrapper purposes topping should be done as high as possible when abundant sunshine and favorable conditions prevail during the growing season. When the weather is cloudy and rainy, topping should be done somewhat lower and a smaller number of leaves left on the plant. This is especially true of shade-grown tobacco, as the shade has a tendency to still further increase the humidity to which the fields are subjected. Experience has shown that instead of breaking off the suckers in the axil it is better to leave a small part of the stem of the sucker about 1 inch in length. In this way fewer suckers will appear. The removal of the suckers throws the strength of the plant into the leaves, but if there is a tendency, through having topped the plants too low or through changed weather conditions, for the leaves of the plant to become too thick this may be counteracted by leaving one or two suckers on the plant. In harvesting it should be noticed that overripe leaves become less combustible, are less elastic, have darker colors, and contain more nicotine, all of which is undesirable. In unripe leaves the colors are difficult to change in the curing process, and often turn from green to black in the fermenting pile. After priming the leaves should be transported to the curing shed, provided with burlap for covering the top and sides, so as to protect the leaves from dust and the direct rays of the sun.

With the cut system of harvesting it is advisable to cut the plants when the middle leaves show maturity; for wrapper purposes early in this stage, for filler a little later.

CURING SHED.

There are five things to be considered in connection with the construction of the best sort of curing shed: Direction, situation, dimension, construction, and ventilation. The direction of the shed should be NNE. by SW., because in Porto Rico the prevailing wind is from

the east. Where the direction of the prevailing wind is different the direction of the shed should conform to it. The shed should be so built that when the ventilators are open the wind will not blow directly in at the openings. When the wind blows directly in at the ventilators the tobacco near by dries too rapidly and the leaves remain green instead of changing to desirable colors. The situation of the curing shed depends upon the requirements of the farm, but, other things being equal, it should be convenient to the tobacco field, and should be as much as possible sheltered by other buildings or trees on the side from which the wind comes. Close proximity to marshes, streams, or wet land should be avoided because the dampness from such sources is conducive to molds and pole sweat. The dimensions of the curing shed will depend upon the size of the crop, but the width should never be too great for good ventilation in all parts of the interior when it is filled with tobacco. The width should not exceed 30 feet and the height should be nearly equal to the width; no definite measurement can be given for the length.

The construction of the curing shed will depend to a certain extent upon the available and most economical material for the structure. In Porto Rico, as a rule, the framework may be of poles cut from native trees. Inch boards of either native or imported lumber will probably be most desirable and cheaper for the sides, while for the roofs either palm leaves or grass is suitable. Thatched roofs favor a more equable temperature than boards. The metals, being good conductors of heat, should not be used for roofing purposes. It is most important that the shed be so constructed that the temperature and humidity can be controlled. In order to accomplish this it should be sufficiently tight to prevent air currents when closed. The ventilators should be at frequent intervals and sufficiently large to secure any desired amount of ventilation. They should be so constructed that they open against the wind and can be readily adjusted to any sized opening quickly or can be tightly closed.

During the early period curing should be effected by slow and continuous ventilation. After the colors are obtained ventilation may become rapid and periodic. The first is had by opening the small ventilators at the bottom and top or side walls or by opening the large ventilators only slightly. The rapid ventilation is effected by opening the large ventilators as wide as possible, always guarding against the direct entrance of wind or sunshine.

The nature of the process which takes place in the curing of tobacco has not yet been thoroughly worked out, but there is a loss of water equal to about 80 per cent of the green weight of the leaves, and a modification of the chlorophyl and other contents of the leaf and the resulting change in color from green to yellow, red to brown. If the leaf cure in a current of hot air, the water is quickly lost and

the color remains green, because sufficient time has not been allowed for the biological process which causes the color changes to take place. If the leaves remain longer in the hot air current, they may also lose their fermenting power. In order to facilitate the transformation of the matter of the leaves a slow curing is necessary. If, however, the circulation of air is too limited, reduction takes place and the leaves turn black, losing their resistance and elasticity. In a general way ventilation should be slow, with a constant circulation of air around all of the leaves, until the parenchyma changes color. Rapid ventilation should be avoided during the early stages of curing, except for short periods after very damp spells, when it may be resorted to in order to drive out the excess of moisture. High temperature and excessive humidity must be avoided.